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An Evaluation of the Effectiveness of Automobile Parts Marking on Preventing Theft

Revised Final Report

July 1, 1999

Prepared for

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Contents

Executive Summary[1]

The nature of car theft changed significantly beginning in the 1970's from joyriding to theft for profit, in large part due to a proliferation of so-called "chop shops" that engage in the volume sale of stolen car parts to body shops, to auto repair shops, and directly to car owners. Because auto theft investigators were often unable to identify from which vehicles the stolen parts came or whether the parts were stolen at all, the Federal Government enacted the Motor Vehicle Theft Law Enforcement Act of 1984 that required automobile manufacturers, based on standards established by the U.S. Department of Transportation (DOT), to mark 14 component parts of selected high-theft automobile lines with identifying numbers. The Federal Anti-Car Theft Act of 1992 required manufacturers to mark an additional 50 percent of their remaining lines. Both statutes permitted the DOT to grant a limited number of exemptions for new automobile lines equipped with selected anti-theft devices.

The 1992 legislation also required the U.S. Attorney General to conduct two assessments of the DOT rules:

(1) conduct by 1997 an initial evaluation of the effectiveness of the parts marking and, if found to be effective in inhibiting chop shop operations and deterring motor vehicle theft, extend parts marking to all remaining vehicle lines by December 1997; and,

(2) conduct by 1999 a long-range review of (a) whether parts marking has been effective in substantially inhibiting the operation of chop shops and motor vehicle theft and (b) whether the anti-theft devices for which the DOT has granted exemptions are an effective substitute for parts marking in substantially inhibiting motor vehicle theft.

Pursuant to the first of these two research requirements, the U.S. Department of Justice's National Institute of Justice contracted with Abt Associates to conduct a two-part study of the legislation's impact.

The first part of the study examined national auto theft data using a cross-sectional time-series design. The second part of the study examined the experiences and opinions of 47 auto theft investigators regarding the effectiveness of anti-theft labels. The 47 investigators represent 31 of the 32 largest cities in the country (plus Miami), six smaller municipalities, and nine State agencies.

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1 This Executive Summary incorporates findings from an earlier report prepared for the National Institute of Justice by Abt Associates Inc. The report is *Opinions of 47 Auto Theft Investigators Regarding Automobile Component Parts Anti-Theft Labels* by Peter Finn, Linda Truitt, and Larry Burton, December 30, 1996.

Findings Based on Automobile Theft Data

The DOT assembled data from two principal sources: The Federal Bureau of Investigations reported automobile thefts by model, model year, state and registration year from 1981 through 1995, and R.J. Polk Inc. provided data on car registrations by model, model year, state and registration year from 1981 through 1995. Taken together, these two files yielded estimates of the automobile theft rate by model, model year, state and registration year from 1984 through 1995. (For reasons discussed in the report, registration years 1981 through 1983 did not enter the analysis.) The DOT indicated which cars were marked. Abt Associates augmented the DOT data by adding information based on Census statistics and FBI Uniform Crime Reports. Abt Associates also analyzed fourteen years of data on automobile theft from the National Household Victimization Survey.

Based on statistical analysis, the study estimated the reduction in automobile thefts attributed to parts marking. Estimates are imprecise, but best estimates are that between 33 and 158 fewer cars are stolen by professional thieves per 100,000 cars that were marked between 1987 and 1995. Those marked cars were among the one-third that would, otherwise, have had the highest theft rates in the Nation. The effectiveness of extending parts marking to average theft-rate cars (as called for by the 1992 Act) is less certain. Because most of those cars have yet to be marked, that effectiveness could not be observed directly.

Estimates of the victim's cost are also imprecise, because victims do not distinguish theft for joyriding (which is unlikely to be deterred by parts marking) from theft by professional thieves. A conservative estimate is that the theft of an automobile by a professional thief costs the average victim about $6,000. This cost excludes insurance reimbursement, and it excludes psychological costs and inconvenience of being a victim.

Marking an automobile costs under $5 per car. Because an automobile is typically used for 10 to 15 years, however, the average cost per year of marking a car is less than 50 cents per car.

Assume that 33 car thefts are prevented every year by marking 100,000 high theft-rate cars, that the cost of a car theft is $6,000 per car, and that the cost of marking each car is 50 cents per year. Then the estimated benefits from marking 100,000 high theft-rate cars is almost $200,000, which compares favorably with paying $50,000 per year to mark those cars. The benefits from extending parts marking to other automobiles is uncertain. Nevertheless, according to our calculations, parts marking would be cost effective if it prevents as few as 8 automobile thefts per 100,000 marked cars. This seems like an achievable target for lower theft-rate cars based on the apparent success rate (at least 33 cars) for marking the parts of high theft-rate vehicles. The implication is that parts marking would be cost effective if extended to cars that were marked as of 1995.

Of course, these estimates could be wrong. Possibly, parts marking is less effective, and victim costs are lower, than estimated here. As explained in the report, the average victim cost is unlikely to be lower than $2,700, which is the average loss from a car theft reported on the National Household Victimization Survey. This means that if as few as 19 car thefts were prevented per 100,000 marked cars, then parts marking would be cost effective. The evidence suggests that parts marking is at least this effective.

The Department of Justice also asked Abt Associates to judge whether anti-theft exclusions were a good substitute for parts marking. For reasons explained in the report, we could not make that judgement, because the data were not adequate to support an inference. Nevertheless, we question the logic of using anti-theft devices as substitutes for parts marking, because they serve different purposes. Anti-theft devices are intended to *harden* a vehicle target, making it more difficult to steal the car. Anti-theft devices probably discourage joyriding, and based on the study, also seem to deter professional thieves. In contrast, parts-marking is intended to assist law enforcement in identifying stolen cars and their parts, and to promote prosecution by building stronger cases. At a cost of somewhat more than $200 per car for anti-theft devices (compared with $5 per car for parts marking), anti-theft devices seem to be a complement to, not a substitute for, parts marking. This conclusion is consistent with the opinions of law enforcement personnel, which are discussed next.

Findings Based on a Survey of Law Enforcement Officers

The conclusions presented in this section are based on telephone conversations with auto theft investigators from 47 jurisdictions, including 31 of the 32 largest cities in the country (plus Miami), six smaller municipalities, and nine State agencies. While the jurisdictions do not represent a random sample of law enforcement agencies across the country, they do include the majority of jurisdictions with the highest auto theft rates in the Nation.

Nearly three-quarters of the 40 big city and State auto theft investigators contacted reported that anti-theft labels are useful in helping to arrest chop shop owners and individuals who steal or traffic in stolen vehicles and parts. Nearly two-thirds of the investigators reported that labels also help them to prosecute chop shop operators and other automobile and parts thieves. Investigators reported that the most serious obstacle to making more effective use of the labels is that they are easy to remove and, once removed, it is impossible to prove that the parts are stolen because the owner cannot be traced. Investigators were about evenly divided regarding whether anti-theft labels deter professionals or amateurs from stealing or stripping cars. Investigators from the six smaller jurisdictions and one rural State report little or no use of anti-theft labels because joyriding, and a resulting high recovery rate of stolen vehicles, is their principal form of auto theft.

A majority of investigators reported that audible alarms, steering wheel "clubs," kill switches, and "smart" keys all help deter auto theft but that each has drawbacks that prevent it from substituting effectively for parts marking. The small minority of investigators who had experience with recovery systems reported that the systems are effective in recovering stolen cars but that their use to date is limited by lack of transmission equipment and cost to the consumer.

All but one investigator felt that the parts marking legislation should be extended to all automobile lines and to all types of noncommercial vehicles, especially pickup trucks. While every investigator reported that the parts that manufacturers are currently required to label are the parts that are stolen most frequently, all but six investigators recommended that additional parts be required to have labels, citing most often seats and airbags. Just over one-third of the investigators recommended that manufacturers be required to stamp vehicle identification numbers (VINs) on the component parts rather than use labels.

Investigators reported making use of three principal types of resources to assist them in making effective use of component parts labels: training, technical assistance, and equipment. Investigators reported they rely primarily on one or both of two organizations for training related to anti-theft labels: the National Insurance Crime Bureau (NICB) and the International Association of Auto Theft Investigators (IAATI). The NICB also assists jurisdictions with auto theft investigations through its computerized database and field agents, many of whom go on site to help local investigators. Local auto theft task forces assist with investigations in nine jurisdictions contacted. Nearly half the jurisdictions use ultraviolet lights to detect counterfeit labels or the footprints that most anti-theft labels are designed to leave if removed.

Findings from the survey suggest that component parts anti-theft labels assist most big city and State auto theft investigators to arrest car and parts thieves and to prosecute them. Investigators were nearly evenly split about the possible deterrent effects of the labels on auto theft, although some reported that the labels deter some chop shop operators. Anti-theft devices are not considered sufficiently effective to warrant labeling exemptions for cars that manufacturers equip with the devices. Almost all investigators would like the parts marking legislation expanded to include not only all remaining car lines but also commercial vehicles and additional parts. Investigators suggested that parts marking might be more effective if auto theft investigators and patrol officers were trained more systematically and frequently in how to investigate label removal and tampering, if legislation in every State made tampering with or removing labels a felony, and if investigators had access to ultraviolet lights.

Introduction

The nature of car theft changed significantly beginning in the 1970's from joyriding to theft for profit, in large part due to a proliferation of so-called "chop shops" that engage in the volume sale of stolen car parts to body shops, to auto repair shops, and directly to car owners. Because auto theft investigators were often unable to identify from which vehicles the stolen parts came or whether the parts were stolen at all, the Federal Government enacted the Motor Vehicle Theft Law Enforcement Act of 1984 that required automobile manufacturers, based on standards established by the U.S. Department of Transportation (DOT), to mark 14 component parts of selected high-theft automobile lines with identifying numbers. The Federal Anti-Car Theft Act of 1992 required manufacturers to mark an additional 50 percent of their remaining lines. Both statutes permitted the DOT to grant a limited number of exemptions for new automobile lines equipped with selected anti-theft devices.

The 1984 Act has received limited evaluation. Using 1987 data, Harris and Clarke (1991a) found that cars designated as "high-theft" models were no more likely to be involved in collisions (which would create greater demand for spare parts) than were other cars, concluding in a separate study (1991b) that parts marking has a limited deterrent effect. The Highway Loss Data Institute (1995), examining insurance industry data, found slightly reduced theft rates for marked vehicles, particularly in urban areas. The Department of Transportation (1991), using National Crime Information Center data from the FBI, could not draw any conclusions concerning parts marking. These evaluations were done shortly after the new regulations went into effect, and before most cars had been marked, which may explain why evaluators could not find a significant relationship between theft rates and parts marking. A recent report by the Department of Transportation (1998) concluded tentatively that parts marking probably was cost effective.

The 1992 legislation also required the U.S. Attorney General to conduct two assessments of the DOT rules:

(1) conduct by 1997 an initial evaluation of the effectiveness of the parts marking and, if found to be effective in inhibiting chop shop operations and deterring motor vehicle theft, extend parts marking to all remaining vehicle lines by December 1997; and,

(2) conduct by 1999 a long-range review of (a) whether parts marking has been effective in substantially inhibiting the operation of chop shops and motor vehicle theft and (b) whether the anti-theft devices for which the DOT has granted exemptions are an effective substitute for parts marking in substantially inhibiting motor vehicle theft.

Pursuant to the first of these two assessment requirements, the U.S. Department of Justice's National Institute of Justice contracted with Abt Associates to conduct a two-part study of the impact of the legislation.

The first part of the study examined the experiences and opinions of 47 auto theft investigators regarding the effectiveness of anti-theft labels.[2] The 47 investigators represent 31 of the 32 largest cities in the country (plus Miami), six smaller municipalities, and nine State agencies. The second part of the study, an empirical evaluation of automobile parts marking on preventing theft, is reported here.

This study has four steps. The first step is to estimate the reduction in automobile theft that is attributable to parts marking and anti-theft devices. The second step is to estimate the dollar costs of stolen cars net of recovery value. The third step is to estimate the cost of parts marking and anti-theft devices. The final step is to compare the cost of marking cars to the estimated savings from preventing thefts through parts marking.

Because this report is necessarily technical, it may be helpful to provide a nontechnical explanation of the analysis. The study identified car models that had never received parts marking and measured trends in their theft rates from 1984 to 1995. The study also identified car models that had been designated for parts marking and examined trends in their theft rates from 1984 to 1995. If parts marking had been effective, we would expect that the theft rates for those marked cars would decrease over time as an increasing proportion of them were, in fact, marked. At the least, we would expect that trends in theft rates for marked cars would compare favorably with trends in the theft rates for unmarked cars. In fact, the analysis showed that theft rates decreased for marked cars, while the theft rate increased slightly for other cars. A rigorous statistical analysis showed that the decrease in theft rates for marked cars was statistically significant, and that parts marking was a likely explanation for that decrease.

The study then analyzed data from the National Household Victimization Survey to determine the costs borne by victims—cars owners and insurance companies—of automobile theft. Estimates of dollar loss were not precise, because the victimization survey does not distinguish between thefts by joyriders (who are unlikely to be deterred by parts marking) and theft by professional thieves and those attempting to defraud insurance companies (who are the target of parts marking). Selecting a low estimate of average victim cost net of recovery value, and comparing this with the cost of marking cars, we concluded that parts marking has been cost effective. Whether extending parts marking to currently unmarked cars would be cost effective is more speculative, obviously, because inferences could not be based on direct experience. Nevertheless, based on demonstrated success marking high-theft cars, evidence

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2 *Opinions of 47 Auto Theft Investigators Regarding Automobile Component Parts Anti-Theft Labels* by Peter Finn, Linda Truitt, and Larry Burton, December 30, 1996.

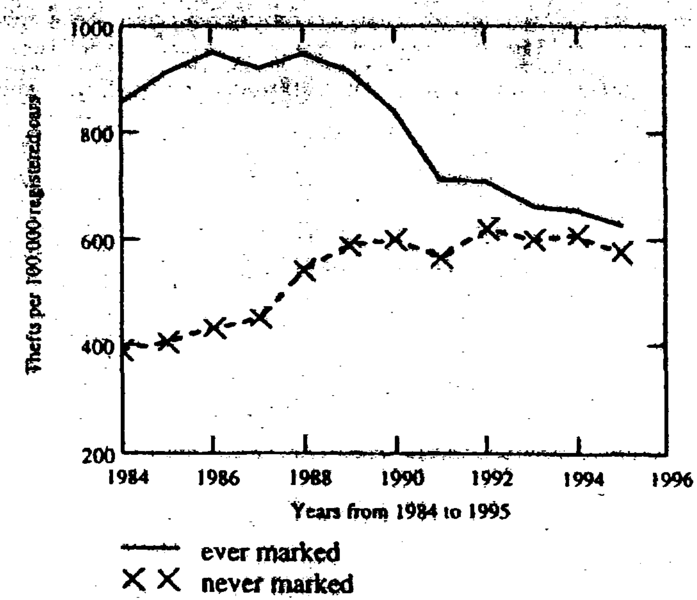
supports a tentative conclusion that extending parts marking to all other cars would be cost effective.

Step One: Parts Marking/Anti-theft Device Effectiveness

Before discussing the statistical analysis, it may be helpful to graph automobile theft rates for two types of cars. "Car Models with Parts Never Marked" are car models that were never designated for either marking or anti-theft exemptions between 1987 and 1995. Our data have as few as 29 million such registered cars in 1984 and as many as 76 million 1995. As explained later, this difference occurs because we could not include model lines that existed before 1981, the earliest year in the data. "Car Models with either Parts Marked or an Anti-Theft Device (ATD) Exemption" had parts marked at some time between 1987 and 1995. Some of the cars may have received anti-theft exemptions that allowed them to discontinue marking parts at a later time. There were 0.8 million cars in 1987 and 26 million in 1995.

Figure 1 shows the theft rates by year for both of these types of cars. For unmarked cars, the theft rate rose slightly before the 1990s and then stayed fairly constant at almost 600 per 100,000 registered cars. For the cars that received a high-theft designation at some time, the rate was about 800 to 900 cars per 100,000 in 1987, and about 600 per 100,000 in 1995. This suggests that parts marking may have been highly effective at reducing automobile theft. However, we need a more rigorous statistical analysis to be confident in the trends that appear in Figure 1.

Figure 1 — Average Theft Rates for Cars with Parts Never Marked and Cars with Either Parts Marked or a Factory Installed Anti-Theft Device



Statistical Model

The National Highway Traffic Safety Administration (NHTSA) provided Abt Associates with car thefts and recovery data by car model, across States, and over time.[3] Variables that enter this analysis are defined as:

[3] The usual term is make and model, but we have reduced this to a shorthand form: model. As an illustration, a Ford Explorer is a model for our purposes. A distinguishing feature of a model is that cars of the same model have interchangeable body parts, meaning that a car from any year within this class has parts that meet the specification for parts for a car from any other year in this class.

S_{ijkm} The number of cars of model i that are stolen in State j during year k. The m denotes the model year. For example, the data report the number of 1993 model-year Ford Explorers that were stolen in Massachusetts in 1995.

S_{ijk} For much of the analysis, we will aggregate over model year, so:

$$S_{ijk} = \sum S_{ijkm}$$

For example, this new variable would tell us the number of Ford Explorers that were stolen in Massachusetts in 1993. The sum is from 1984, the first year in the data, to k (1993) in the example. This analysis seeks to explain changes in S_{ijk} as a function of parts marking and factory-installed antitheft devices.

N_{ijk} The number of cars of model i that are registered in State j during year k. The number of registered cars is a measure of the number of cars that are *at risk* of being stolen. Unfortunately, our data about registrations overstates the number of cars at risk. New cars may have been registered for just a few months (1994 Ford Explorers that were registered in 1993 are illustrations), and old cars may have been retired during the year but still appear as having been registered during the entire year. We explain later how we adjusted the registration data to account for this overstatement.

R_{ijk} The automobile theft rate for model i in the jth State during the kth year, defined as S_{ijk} divided by N_{ijk}.

We seek to estimate the expected value of S_{ijk} :

$$E(S_{ijk}) = N_{ijk} e^{\alpha_{ij} + X_{ijk}\beta + M_{ijk}\delta + A_{ijk}\gamma} \qquad (1)$$

where:

α_{ij} A fixed effect that varies by model i and State j. Thus, other things equal, the theft rate will vary by car model and by State. It will also vary over time, but that later variation is captured by other variables.

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4 The data report model years as of 1981, so no car of model year earlier than 1981 entered the analysis. The data report registrations as of 1984, so no registration year earlier than 1984 enters the analysis. Of course, most 1981 model cars were still registered as of 1984.

δ — A parameter representing the reduction in the theft rate that can be attributed to parts marking

M_{ijk} — The percentage of cars of model i that were marked in State j during year k. Before 1987, this number was zero.

γ — An effect attributable to anti-theft devices.

A_{ijk} — The percentage of cars of model i that had factory installed anti-theft devices in State j during year k.

β — A parameter vector that captures variation in theft rates attributable to factors that vary across time within a State. The α parameters are expected to capture effects that are specific to a State but which do not vary over time.

X_{ijk} — A vector of exogenous factors that help explain automobile theft rates. A list of such variables will receive attention later.

Analysis File

To be included as a stolen car in these data, the theft had to be reported to the FBI. According to the National Criminal Victimization Survey (1986-1992 data), 93 percent of all automobile thefts are reported to the FBI, which serves as a national clearinghouse for identifying stolen cars. Car registration data come from R.L. Polk and Company. The data were assembled by KRA Corporation under contract to NHTSA (KRA, 1997).

This model is estimated using pooled cross-sectional time-series data. The cross-section has two dimensions—the State and the car model. The definition of a State is obvious. A car model is a dealer model (such as a Ford Explorer) that has not undergone structural changes. That is, if Ford Explorers from 1985 through 1990 had common body parts, and if Ford Explorers from 1991 through 1995 had common body parts, but if the 1985–1990 Explorers differed from the 1991–1995 Explorers, then we considered these as being two distinct models for our purposes. This definition was adopted because our interest centered on cars that were stolen so their parts could be resold as replacement parts for cars of the same model. The time series is measured in years from 1984 through 1995.

Using this definition, there were hundreds of car models. Given that there were 50 States and 12 years, there were potentially tens of thousands of data points. In fact, however, the analysis files were considerably smaller. First, the analysis file comprised car models that were deemed high theft automobiles. Given the use of a fixed effect model, cars that never had parts marked could not contribute directly to the parameter estimate δ. Thus, a desire to reduce the computing burden argued for excluding low theft-rate cars from the analysis file.

Second, we eliminated a few car/state combinations because no cars were stolen between 1984 and 1995, so the fixed effect explained everything. Third, we eliminated car models that existed for fewer than two years because these contributed nothing to the estimation. Fourth, we were forced to eliminate car models that existed in 1984 and later if they also existed in years earlier than 1981. Available data lumped those early-year models into an undifferentiated set so we could not compute the requisite theft rates for individual car models. Fifth, we eliminated cases when there were fewer than 100 registered cars of a given model in a given year. We were forced to eliminate a few cases with missing data.

Finally, we had to make some modifications to the car registration data. This adjustment forced us to exclude some additional data. Let:

> P_{ijkm} = the number of cars of model type i, model year m, that were reported as registered in State j during year k.

Registrations for cars of model year m, where m is greater than k, are not reported reliably in the Polk data. For example, 1995 Ford Explorers registered in 1994 were not reported in the data. Our decision was to exclude from the analysis file all registrations and thefts for cars where $m > k$. We had to make one additional adjustment to the registration data. P_{ijkm} represented only the first six months of registrations when $k = m$. For example, available data reported only the first six months of car registrations for 1994 Ford Explorers registered during 1994. KRA recommends multiplying P_{ijkm} by 1.495 to get the total number of registrations for year k when $k = m$. But there is an additional problem because some of the cars registered during the first six months were registered at the beginning of the year, some at the end of six months, and most at times in between. The same problem exists for cars registered during the last six months. To estimate the number of cars on the road during year k, we computed

$$N_{ijkm} = 0.75\, P_{ijkm} + 0.25\ ADJ_m\, P_{ijkm}$$

when $k = m$, and

$$N_{ijkm} = P_{ijkm}$$

when $k > m$; where

> ADJ_m is the adjustment ratio (0.495) for estimating registrations for the last six months from registrations for the first six months—that is, the adjustment recommended by Polk.

The 0.75 adjustments reflects an assumption that cars registered during the first six months were on the road for an average of 9 months, or 0.75 years. The 0.25 adjustment reflects the assumption that cars that were registered during the last six months were on the road for an average of 3 months, or 0.25 years.

Discussion of the Model

Distinguishing joyriding from for-profit thefts. Many auto thefts seem to be either theft from a vehicle or theft by minors (or others) for joyriding. These forms of theft are not likely to be deterred by parts marking. The other type is theft for profit. Thieves sometimes intend to resell a stolen car, usually out of this country, but often they plan to strip the car of valuable parts which are then sold as replacement parts for damaged cars of the same model.[5] Theft for profit, the target of parts marking, is the focus of this evaluation. The dependent variable does not distinguish between joyriding and theft for profit. Nevertheless, we do not expect parts marking to reduce joyriding, so any reduction in auto theft attributed to parts marking must be a reduction in thefts for profit.

We also specified the dependent variable EQ(1) in one other way intended to reflect theft for profit. Define:

$$S_{ijkm}^{C} = (1 - C_{ijkm})S_{ijkm}$$

where:

C_{ijkm} Is the proportion of cars of model i (model year m) in the j^{th} State during the k^{th} year that were stolen but recovered in whole or in part.

S^{c}_{ijkm} Is the number of cars of model i (model year m) that were stolen and not recovered in State j during year k.

S^{c}_{ijk} Is the sum of S^{c}_{ijkm} over m.

As a measure of theft for profit, S^{c}_{ijk} suffers several deficiencies. A theft for profit can result in a car being returned to its owner or to the insurance company that has rights to the car after paying the owner's claim. The recovered car may comprise nothing more than a frame. In such a case, theft for profit would seem to be the motivation, but that would not be reflected in S^{c}_{ijk}. A second problem is that parts marking may allow frames and other body parts to be identified for marked cars, and hence, be classified as recovered. For cars without parts marking, the same parts may have been unidentified and thus classified as not recovered. For these two reasons, S^{c}_{ijk} probably understates the number of thefts-for-profit, as well as trends in crimes for profit. Using S^{c}_{ijk} in the regression analysis probably leads to parameter

5 Disposing of a stolen car takes many forms beyond those mentioned here. For example, an insurance fraud may work by reporting a car as stripped of its parts, selling the frame to a junk yard, and then replacing the parts on that frame. Because the frame carries the vehicle identification number, the reassembled car can then be registered.

estimates that have a downward bias. Consequently, this report emphasizes the analyses based on S_{ijk}, the theft rate for all cars, and uses results from an analyses of R^c_{ijk} to establish some lower limits.

Effects vary over time. According to our interviews with law enforcement agencies, police did not react immediately to the advent of parts marking. They had to learn that parts marking had been implemented, they had to be trained how to use parts marking (mostly by institute staff funded by insurance companies), and in some cases they had to purchase equipment (such as infrared reading devices). The impact of parts marking may have been delayed as enforcement agencies learned to use the law. Other things equal, this implies that parts marking should have become more effective over time, so that the parameter δ should increase over time.

Of course, thieves may have become better over time at evading the law, and this effect may mitigate against an increasing value of δ. We know of one specific illustration of this problem. Except for the engine block and transmission, car parts are marked with tape that is supposed to leave an indelible trace if removed. The tape that was used initially was not totally effective, and skilled thieves reportedly could remove it without leaving a trace. Improved tape was introduced over time. This suggests that δ might have increased initially as police got better at using parts marking, decreased subsequently as thieves got better at overcoming parts marking, and then increased again as markings improved.

These arguments not withstanding, our earlier report (Rhodes, Norman and Kling, 1998) found no trends in the effectiveness of parts marking. Based on the principal of parsimony, we have assumed that a single δ parameter, rather than a time-varying δ parameter, was appropriate for the analysis.

Covariates

Although the concern of this evaluation is with the effectiveness of parts marking and anti-theft devices, the analyses is more convincing when it controls for other factors that have influenced theft rates over time. Factors that are specific to a State and car model, specifically those factors that remain constant over time, are captured in the fixed effects—the α parameters. This analysis seeks to control for factors that vary over time within a State.

Variables entering this statistical model represent factors that vary over time within a State:

TOTINDEX	The per capita index crime rate exclusive of automobile theft in State j during year k.
SAMEPCT	The percentage of the automobile stock for model i in State j during year k that were of model year k. This variable was introduced into the regression because the number of cars of model i, State j, registration year k, model year k were believed to be inaccurate.
ONEPCT	Same as SAMEPCT, but the registration year was k and the model year was k−1.
REGPERCP	The number of per capita registrations of model i in State j during year k.
DENSITY	Percentage of the population living in urban areas. It seems plausible that problems with crime become more or less serious in a State as it becomes increasingly urbanized.
POP18_24	Percentage of the population aged 18 to 24. Joyriding would seem to be most prevalent among youths and young adults. Thus, we would expect theft rates to increase or decrease as a State's population becomes younger or older.
AGESTOCK	At any time, in any State, the number of cars of model type i (N_{ijk}) has a distinctive age composition. Some cars are fresh from dealers' lots; others are ten or fifteen years old. The age composition of the stock of cars of model i in State j and year k may reflect the desirability of that stock as theft targets. Newer cars would seem to have the greatest resale value. Then again, replacement parts may become increasingly valuable as the stock ages. Moreover, joyriders may find that older cars are better targets because owners become less diligent about protecting their investment as that investment falls in value. We are uncertain about the relationship between theft rates and AGESTOCK, so we introduce an additional variable into the regression, AGESTK2.
AGESTK2	This is the square of AGESTOCK. By introducing AGESTOCK and AGESTK2 in the model, the statistical model allows the relationship between R_{ijk} and AGESTOCK to be non-linear.

To derive AGESTOCK, we computed:

$$AGESTOCK_{ijk} = \frac{\sum_{m=1981}^{k} N_{ijkm}(k-m+1)}{N_{ijk}}$$

This formulation assigns an age of 1 to 1994 Ford Explorers (m = 1994) registered in 1994 (k = 1994), an age of 2 to 1993 Ford Explorers (m = 1993) registered in 1994 (k = 1994), and so on for other years and other car models.

MARK — This is the same as M, the percentage of marked cars.

ATD — This is the same as A, the percentage of cars with factory installed anti-theft devices.

TREND — The rate at which cars not deemed to be high theft rate cars were stolen in each state during each year.

TIME — A time trend variable. Some of the analysis also uses TIME2, equal to the square of TIME, and TIME3, equal to the cube of TIME.

Estimation

Our original analysis following an approach suggested by Baltagi (1995, 83), but further investigation of that analysis showed that parameter estimates were unduly sensitive to a few car models and years that had extremely high leverage. We decided to abandon that approach in favor of a fixed effects poisson regression (Cameron and Trivedi, 1998). Estimation was done by conditional maximum likelihood (Cameron and Trivedi, 1998, 282; Greene, 1997, 940). This estimation routine was programmed using GAUSS software routine Maximum Likelihood (Aptech Systems Inc., 1996).

The generic (before conditioning) form of the likelihood is:

$$P(S_{ijk}) = \frac{\lambda_{ijk}^{S_{ijk}} e^{-\lambda_{ijk}}}{S_{ijk}!} \tag{3}$$

where $P(S_{ijk})$ is the probability that S_{ijk} cars are stolen and

$$\lambda_{ijk} = e^{\alpha_{ij} + \ln(N_{ijk}) + X_{ijk}\beta + M_{ijk}\delta + A_{ijk}\gamma} \tag{4}$$

where N_{ijk} is the number of cars registered. It has a parameter constrained to zero. See Cameron and Trivedi for how this generic likelihood can be rewritten as a conditional likelihood.

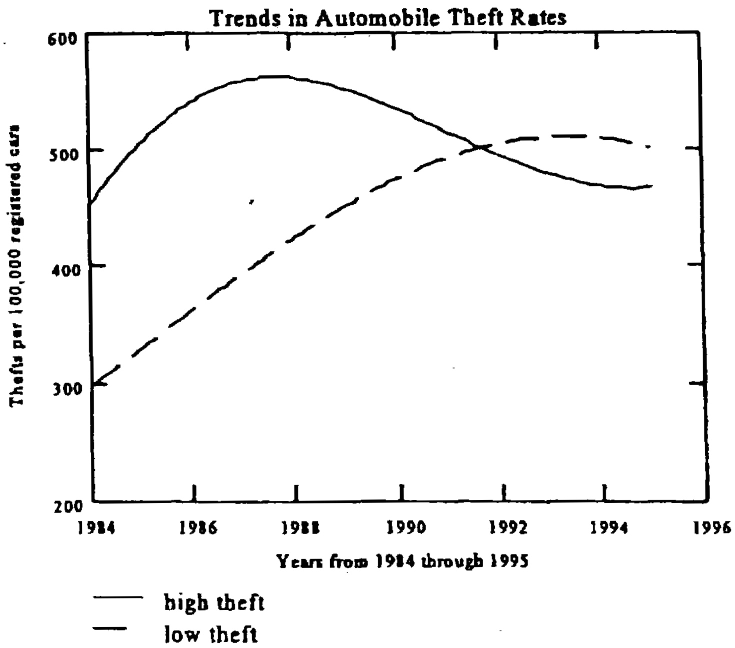
In this approach, estimates of δ and γ are based exclusively on variation within a State and model. Cars that were never marked, or never had anti-theft waivers do not contribute any direct information to the measurement of δ and γ. For this reason, only those cars deemed high theft automobiles (and hence subject to marking) were included in the analysis.

We estimated two general regressions. The dependent variable in the first general regression is the number of cars stolen (S_{jk}). The dependent variable in the general second regression is the number of cars that were stolen and not recovered (S^c_{ijk}). In both cases, we report variations on the two basic regression specifications.

Interpretation

Has parts marking deterred automobile theft? This is a deceptively difficult question to answer. We observe that automobile theft rates decreased or continued to decrease as more and more automobiles had their parts marked. We cannot be sure, however, whether or not that observed trend would have happened in the absence of parts marking. The best we can do is to use statistical analysis to draw inferences from the data at our disposal.

Figure 2 — Trends in Automobile Theft Rates, High Theft-Rate and Low Theft-Rate Models, Controlling for Model and State



As discussed, the statistical technique upon which most of our inferences rest is called a fixed effects poisson model. The technique controls for model type and state. A simple application of this poisson model is to estimate how automobile theft rates changed as a function of time. Figure 2 shows years beginning in 1984, the earliest year for which we have data, and ending in 1995, the last year for which we have data. (Table 1 reports regression results upon which figure 2 is based.) The vertical axis shows the estimated theft rate per 100,000 registered cars based on predictions from the poisson model. Thus, the curves represent the average theft rate across model and state combinations.[6]

Table 1

Parameter Estimates and Standard Errors from Regressing Thefts on Time

	All thefts of high theft-rate automobiles		All thefts of low theft-rate automobiles		Unrecovered thefts of high theft-rate automobiles		Unrecovered thefts of low theft-rate automobiles	
	estimate	t-score	estimate	t-score	estimate	t-score	estimate	t-score
TIME	2.25	44.13	1.35	27.86	-0.42	-1.12	1.76	4.42
TIME POWER 2	-4.03	-43.00	-0.53	-5.96	10.92	9.55	8.51	7.06
TIME POWER 3	1.98	37.68	-0.20	-4.05	-22.00	-15.54	-19.80	-13.43
TIME POWER 4					11.99	19.76	11.04	17.65

The first curve is a smoothed representation of the theft rates for automobiles that were ever deemed to be high theft-rate automobiles by the NHTSA. (These were identified because they were required to have parts marking or anti-theft device waivers at some time during the model line's life.) The smoothed curve shows that the theft rate had been increasing before parts marking was instituted in 1987. The theft rate leveled off just before parts marking was instituted. And then as more and more high theft cars were marked, fewer and fewer were stolen.

By itself, this evidence is not convincing that parts marking was effective. One problem is that the theft rate stabilized before any cars were marked, and the theft rate began to fall before more than a small percentage of cars had been marked. Quite possible this favorable turn in automobile theft rates had nothing to do with parts marking.

The second curve shows a smoothed version of the trend in automobile theft rates for cars that had never been deemed to be high-theft rate cars. Because these cars were never marked, the program to mark automobile parts should have had no effect on their theft rates. The theft rate for these automobiles also reached a peak and began to decline, but not until about 1992 or 1993. If the trend in theft rates for low theft rate cars reflects the trend that would have prevailed for high theft-rate cars in the absence of parts marking, then the evidence is consistent with the conclusion that parts marking deterred theft.

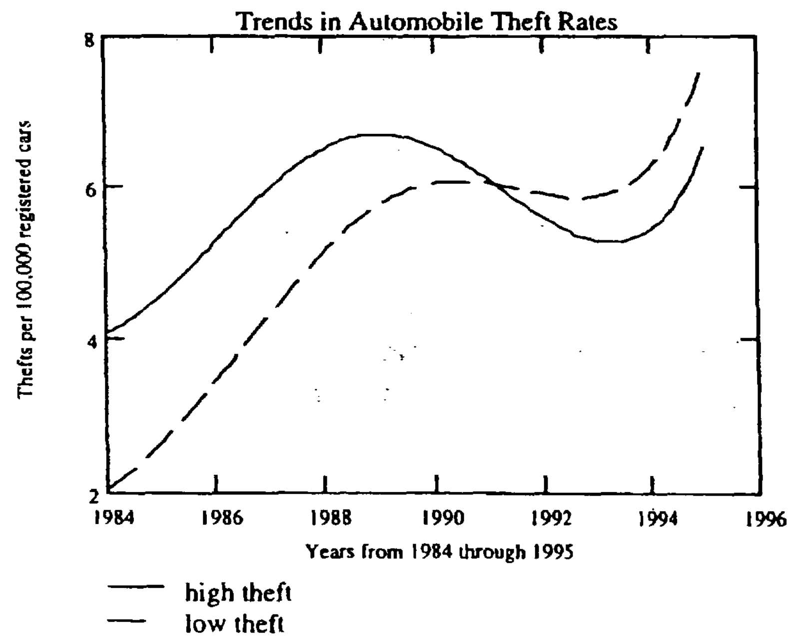
6 The curves in this figure differ from their counterparts in figure 1. The statistics reported in figure 1 were computed by dividing the number of cars stolen by the number of cars registered and then converting the resulting rate to thefts per 100,000 registered cars. The statistics reported in figure 2 are the average across all car models after controlling for State and model. Thus, figure 1 give more weight to car models with the largest number of registrations and figure 2 give equal weight to each car model regardless of the registration volume.

Another way to examine theft rates is to focus on the thefts of cars that were never recovered. Figure 3 is the same as figure 2, except that the trends are based on cars that were never recovered instead of all stolen cars.

The timing of the decrease in thefts is consistent with the advent of parts marking. Automobiles were at the highest risk of being stolen (and not recovered) between 1988 and 1989, the same time as parts marking was being introduced. Theft rates decrease as more and more cars had their parts marked. This decrease in the theft rates seems to have reversed during the last year, but we tend to discount that evidence. Essentially it rests on a single time point and probably overstates the apparent reversal.

Examining the comparable theft rate for cars that were never deemed high theft-rate automobiles, we see that the peak in thefts rates occurred somewhat later than that of their high theft counterparts, but not by much. More important, there was no apparent downturn in the theft rates for those low theft automobiles corresponding to the downturn in the theft rate for the high theft cars. After 1988, and prior to the last year in this data series, the number of thefts was relatively flat.

Figure 3 — Trends in Unrecovered Automobile Theft Rates, High Theft-Rate and Low Theft-Rate Models, Controlling for Model and State



Assuming that trends for low theft rate cars are a surrogate for trends in high theft rate cars absent parts marking is a strong assumption, however, and we would like to have better evidence. Furthermore, the time-series reflects the combined effects of anti-theft devices as well as parts marking. The time-series cannot tell us how much of an effect to attribute to parts marking.

Putting the trend aside temporarily, and placing the focus on the statistical models with covariates, the simplest statistical model has only one independent variable—the percentage of cars that are marked in a car model/state combination. This simple model implies a large effect attributable to parts marking—about 158 fewer stolen cars per 100,000 marked cars. This is not very compelling evidence however. We know that theft rates were declining after 1987 for high-theft automobiles. We know that parts marking was instituted in 1987 and that an increasing number of cars were marked thereafter. We would expect to find a high correlation between theft rates and the use of parts marking. Such a straightforward analysis cannot tell for sure whether parts marking caused lower theft rates, or whether parts marking was merely coincident with lower theft rates.

More compelling is the evidence that emerges after we have added additional variables to control for factors other than parts marking that might account for the observed trends. With this purpose in mind, we added the following variables to the model:

- Percentage of cars that received anti-theft exemptions
- The age of the stock of cars in a model/state configuration.
- The percentage of the population that lives in urban areas.
- The percentage of the population between the ages of 18 and 24.
- The number of car registrations per capita
- The index crime rates.
- Control variables that correct for problems with the data assembly.

Table 2 reports the parameter estimate associated with parts marking, but that parameter estimate cannot be interpreted by simple inspection. To provide an interpretation, note that:

$$E(S) = Ne^{\alpha_i + X\beta + \gamma M}$$

This expresses the expected value of the number of car thefts as a nonlinear function of the number of car registrations (N), control variables (X), and the percentage of cars that were marked (M). The Greek letters represent parameters including α which represents the fixed effect. On average, about 550 high theft-rate cars were stolen per 100,000 registered cars between 1984 and 1995. This implies that on average:

$$Ne^{\alpha_i + X\beta + \gamma M} = 550$$

To estimate the effect of parts marking, we differentiate the expectation to get:

$$\frac{\partial E(S)}{\partial M} = Ne^{\alpha_i + X\beta + \gamma M}\gamma$$

Evaluating this expression at the mean gives:

$$\frac{\partial E(S)}{\partial M} = 550\gamma$$

Substituting γ=-0.06 from table 2 gives an estimate of the reduction in the number of automobile thefts resulting from marking 100,000 cars. Once the additional variables were introduced into the model, the effect associated with parts marking dropped to 33 car thefts prevented per 100,000 marked cars.

The size of the estimate is approximate and, probably, conservative because we evaluate this derivative at the average value between 1984 and 1995 rather than the highest value between 1984 and 1995. Arguably, parts marking caused the theft rate to fall from its highest value, which would justify a higher estimate for the effect from parts marking. The more conservative estimate is adequate for our purposes, however.

Table 2

Parameter Estimates and T-Scores from the Poisson Regressions on Automobile Thefts Rates Conditioning on Model and State

	estimate	t-score	estimate	t-score	estimate	t-score	estimate	t-score
PERCENT MARKED	-0.06	-5.81	-0.30	-28.60	0.36	27.78	-0.23	-20.50
PERCENT ANTI-THEFT	-0.50	-43.98	-0.48	-41.47	-0.20	-15.18	-0.47	-40.24
AGESTOCK	0.44	8.06	-0.11	-2.09	3.97	50.29	0.05	0.96
AGESTK2	-0.50	-8.49	-0.01	-0.13	-2.18	-33.68	-0.11	-1.80
ONEPCT	-0.12	-10.25	-0.10	-8.87	0.03	2.50	-0.11	-9.35
DENSITY	2.28	32.11	1.69	23.62	3.38	46.03	2.34	32.61
POP18_24	5.09	18.39	3.97	14.21	7.11	23.09	6.03	20.65
REGPERCP	0.01	5.95	0.02	13.41	0.03	16.26	0.02	11.46
SAMEPCT	0.13	10.68	0.13	10.27	0.36	28.19	0.15	12.16
TOTINDEX	16.24	68.79	6.70	26.78	14.02	52.96	10.83	41.86
TREND			0.41	110.02			0.24	78.59
TREND POWER 2								
TIME					1.39	21.57	1.91	18.36
TIME POWER 2					-6.20	-58.22	-3.55	-8.99
TIME POWER 3					3.59	60.16		

There is no guarantee that the control variables account for the entire trend. Consequently, we added one additional control variable:

- The theft rate within a state and year for all cars that NHTSA had never labeled as high theft-rate vehicles.

The reasoning was that these latter vehicles could not have been affected by parts marking, so they provided a comparison group whose theft trend rates could be compared with the theft trend rates for cars that had been designated for marking. With this variable introduced into the model, the statistical analysis suggests that marking 100,000 cars prevents 165 automobile thefts.

One additional model seemed to be appropriate for these data. Instead of using the rate of automobile thefts for the low theft-rate vehicles as a trend variable, we introduce time itself as a trend variable. The model now includes:

- Time
- Time squared
- Time Cubed

With this change, the salutary effects attributed to parts marking disappear from the analysis. In fact, parts marking now appears to *cause* 198 car thefts per 100,000 marked cars. This is a nonsense conclusion because there is no reason to suppose that parts marking would lead to more stolen cars.

We presume this apparently perverse effect arises from model misspecification. In this case, the way we have modeled the relationship between stolen cars, marked cars, and control variables cannot be exactly correct. When both time and marked cars are introduced into the model, the error in the model specification seems to interact so as to produce conclusions that are counterintuitive, in conflict with all other model specifications, and unlikely to imply anything about the true relationship between parts marking and automobile theft. Whatever the explanation for the counter-intuitive effects reported above, adding the trend variable to the time variables recovers results that are consistent with the conclusion that parts marking deters automobile theft.

The alternative way to examine automobile theft rates is to use unrecovered automobile as the dependent variable. In this analysis, we used all the independent variables that were included above (excluding the time trends) but in place of the theft rate for cars that were never deemed high theft we substitute the theft rate for *unrecovered* cars that were never deemed high theft rate automobiles. Results are reported in table 3.

Using the same model specification as above (except, the trend is now the rate of thefts for low theft rate models that were not recovered), parts marking had a coefficient that was not statistically significant. When we added the square of the theft rate for low theft rate cars to the statistical model, however, the effect was statistically significant and suggested that parts

Table 3

Parameter Estimates and T-Scores for Poisson Regressions on Unrecovered Stolen Cars Conditioning on Model and State

	estimate	t-score	estimate	t-score
PERCENT MARKED	0.03	0.79	-0.21	-6.78
PERCENT ANTI-THEFT	-0.21	-5.69	-0.24	-7.25
AGESTOCK	-2.14	-13.51	-0.97	-6.64
AGESTK2	2.36	13.99	0.93	5.96
ONEPCT	-0.25	-7.89	-0.14	-4.73
DENSITY	-1.57	-6.83	-0.68	-3.03
POP18_24	2.00	2.14	4.02	4.72
REGPERCP	0.03	5.07	0.02	4.26
SAMEPCT	-0.40	-11.03	-0.16	-4.81
TOTINDEX	4.82	6.42	5.05	7.64
TREND	1.10	75.26	3.04	92.38
TREND POWER 2			-0.88	-65.71

marking reduced theft of unrecovered vehicles by about 20 percent. This is only 1.4 cars per 100,000 marked, but the base rate of 6.73 cars stolen on average is probably too low for reasons explained in the text. A higher base rate would yield a larger estimated effect.

We cannot feel confident that the statistical analysis accurately estimates the effect of automobile parts marking. Changes in the model specification—sometimes even subtle changes in the model specification—lead to different estimates of how parts marking reduces automobile theft. Nevertheless, the evidence is consistent with the conclusion that parts marking does reduce automobile theft, even if the size of the effect is uncertain. The next section raises and answers the question: How small of an effect would justify the conclusion that parts marking is cost effective? Does the size of that critical value comport with the evidence presented here?

Step 2: Cost of Car Theft

Conducted by the Bureau of Justice Statistics, the National Criminal Victimization Survey (NCVS) is useful as an indicator of the severity of motor vehicle theft in this country. The NCVS interviews approximately 49,000 households (about 101,000 individuals) annually. Households are interviewed every six months during a three year period, and new households are rotated into the sample over time. By interviewing victims of theft, the NCVS complements law enforcement data which records only reported crimes. It is also useful in conjunction with insurance industry data as the NCVS records thefts unreported to insurance companies.

The NCVS asks a representative household member whether any member of the household had an automobile stolen in the six months before the survey. If a car was stolen, an interviewer asks the respondent about the dollar value of the stolen car and the car's value after recovery. The interviewer also asks whether the theft was reported to the police or to an insurance company. If the theft was reported to an insurance company, the interviewer asks about reimbursement.

Respondents seemed to have trouble answering these questions. We found many responses where the respondent said that the car's value was the same when stolen and when recovered, yet the insurance company paid restitution. Our assumption was that the respondent subtracted the restitution from the recovered loss, so we set loss equal to insurance payment whenever insurance restitution was greater than or equal to the reported loss. This solution is imperfect, because insurance payments are grossly understated in the NCVS. When compared with the average payment for car theft reported by the Highway Loss Data Institute, respondents to the NCVS report only one-tenth of the average insurance reimbursement.

This raises the question of whether the NCVS is a reliable source for automobile theft statistics. To answer that question, Figure 4 shows the annual number of car thefts from households according to the NCVS and the annual number according to the FBI.

We would not expect the two sources to agree perfectly. The NCVS is a survey, so it has some sampling error, while the FBI source is an enumeration. Also, according to the NCVS, only 93 percent of car theft victims report their loss to the police, so we would expect the NCVS to show more thefts than appear in the FBI data. In fact, the FBI data tend to show more thefts, but that difference is explainable. The NCVS does not report car theft from business and government, which would cause the FBI source to record more thefts. At any rate, Figure 4 shows the NHVS and FBI to be in substantive agreement after these differences between the data are taken into account.

During 1994, households reported almost 1.2 million car thefts (see Table 4). This was more than the 0.9 million in 1981, but fewer than the reported car thefts at the turn of the decade. The total value of cars stolen in 1994 was almost $7 billion, or over $6,000 per car. Roughly 70 percent of the value of stolen cars was recovered (57 percent of the cars were recovered), so the net theft loss was about $3 billion, or nearly $3,000 per car.

The information in Table 4 was compiled from three different versions of the NCVS. Although each version has methodological differences, they do not overly affect motor vehicle theft data. The main incompatibility between the data sets is revealed by the absence

Figure 4
NCVS and FBI Data

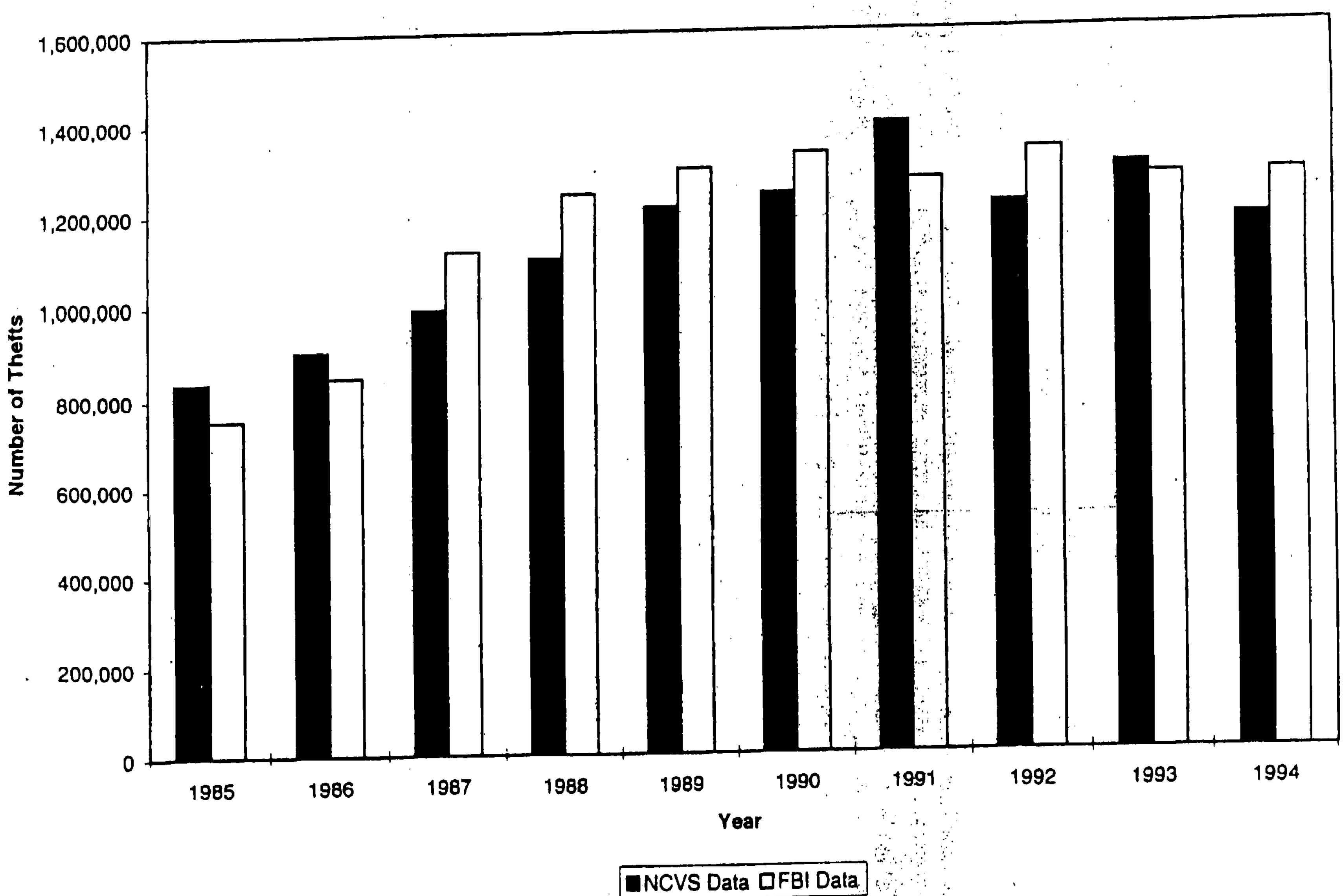


Table 4

National Criminal Victimization Survey Data for Auto Theft 1981-1994

	1989	1990	1991	1992	1993	1994
Total Incidents	1,209,959	1,239,467	1,393,864	1,203,242	1,296,812	1,179,147
Total Value of Property Taken	$7,186,844,161	$7,932,569,723	$8,074,861,984	$7,211,294,402	$7,460,569,997	$6,778,002,059
Average Loss per Incident	$6,296	$6,725	$6,103	$6,399	$6,079	$6,247
Total Recoveries (Whole or Part)	654,657	753,475	838,934	872,140	849,189	827,451
Total Monetary Amount Recovered (Whole or Part)	$4,337,414,532	$6,169,130,050	$5,888,317,702	$4,378,127,757	$3,989,945,911	$3,876,150,676
Average Monetary Amount Recovered (Whole or Part)	$3,696	$5,115	$4,318	$3,849	$3,203	$3,501
Percent Recovered (Whole or Part)	54%	61%	60%	72%	65%	70%
Percent of Thefts Recovered (Whole or Part)	60%	78%	73%	61%	53%	57%
Net Theft Loss	$2,849,429,629	$1,763,439,673	$2,186,544,282	$2,833,166,645	$3,470,624,086	$2,901,851,383
Average Theft Loss	$2,600	$1,610	$1,785	$2,550	$2,876	$2,746
Number of Thefts Reported to Insurance	686,688	782,413	849,138	697,776	733,652	659,813
Number of Thefts Reported to Insurance Recovered	430,968	565,899	578,555	481,561	466,620	444,022
CPI Adjusted Average Loss (1994 Dollars)	$3,027	$1,781	$1,923	$2,690	$2,965	$2,746

Table 4

National Criminal Victimization Survey Data for Auto Theft 1981-1994

	1981	1982	1983	1984	1985	1986	1987	1988
Total Incidents	904,106	958,066	818,211	841,692	835,515	897,739	995,669	1,101,021
Total Value of Property Taken	$2,878,523,247	$3,275,850,082	$3,265,847,991	$4,038,650,338	$4,355,148,576	$4,389,901,653	$5,373,503,074	$6,325,344,836
Average Loss per Incident	$3,348	$3,585	$4,230	$5,272	$5,637	$5,304	$5,582	$6,077
Total Recoveries (Whole or Part)	586,481	592464	528,867	569,936	559,174	419,752	620,208	695,222
Total Monetary Amount Recovered (Whole or Part)	$1,441,333,734	$1,642,588,211	$1,710,995,255	$1,927,660,989	$2,405,052,354	$2,426,103,820	$3,603,807,522	$4,468,277,927
Average Monetary Amount Recovered (Whole or Part)	$1,689	$1,806	$2,241	$2,503	$3,188	$3,019	$3,943	$4,176
Percent Recovered (Whole or Part)	65%	62%	65%	68%	67%	47%	62%	63%
Percent of Thefts Recovered (Whole or Part)	50%	50%	52%	48%	55%	55%	67%	71%
Net Theft Loss	$1,716,189,202	$2,007,670,864	$1,862,795,999	$2,543,465,320	$2,628,509,947	$2,393,241,679	$1,769,695,552	$1,857,066,909
Average Theft Loss	$1,659	$1,779	$1,989	$2,769	$2,449	$2,285	$1,639	$1,901
Number of Thefts Reported to Insurance	N/A	N/A	N/A	N/A	N/A	N/A	578,268	637,472
Number of Thefts Reported to Insurance Recovered	N/A	N/A	N/A	N/A	N/A	N/A	403,038	460,690
CPI Adjusted Average Loss (1994 Dollars)	$2,324	$2,407	$2,631	$3,514	$3,031	$2,968	$2,067	$2,321

of data listed in the table concerning insurance reporting by theft victims. The 1979 through 1986 data set did not ask sufficiently similar questions as to be comparable with the other two more recent data sets.

In compiling these data, a motor vehicle theft incident included an incidence of car theft, other motor vehicle theft, or motor vehicle parts theft. Similarly, all monetary amounts listed (both aggregate and average) are for all three types of motor vehicle theft. Except for the last line of the table (CPI Adjusted Average Loss), dollar figures have not been adjusted for inflation.

The benefit from preventing an automobile theft is, roughly, the dollar cost incurred by the victim when his or her car is stolen. We say roughly because there are additional costs stemming from the psychic costs of being a victim, the time associated with reporting the loss to police and insurance companies, and the inconvenience—at least temporarily—of being without a car. These are real, nontrivial costs, but they are not considered here.

Even discounting these nonpecuniary costs, estimating the benefit from preventing an automobile theft is not as straightforward as determining the dollar costs of the average car theft. The average loss from a car theft is based on those cars that were taken for joyriding, and were recovered with little or no loss, and those cars that were taken by professional thieves, and were either not recovered or were recovered with large losses. Because parts marking is expected to reduce thefts by professional thieves, and have little effect on the theft rate for joyriding, using the average loss from a car theft to evaluate the benefits from parts marking would surely understate the benefits of marking automobile parts.

Although the data do not differentiate between joyriding and professional theft, they do tell us that between 1987 and 1992 the average loss from an automobile theft was about $2,700. Many stolen cars are returned without being damaged, so the victim incurs no financial loss (as measured here). But cars stolen by professionals are unlikely to be returned without some damage, so the $2,700 is too low of an estimate for cars stolen for chop shop operations. When the estimate is based on dollar loss when there is *some* dollar loss, the average jumps to $4,400.

There is some confirmation for these loss estimates. The Insurance News Network,[7] reporting statistics collected by the Highway Loss Data Institute, says that the average claim paid by insurance companies between 1992 and 1994 was $4,081. Of course, owners typically pay a deductible, so the dollar loss was probably closer to $4,400 per claim based on the NCVS data.

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7 Insurance New Network, downloaded from the Internet, April 27, 1997: WWW.INSURE.COM/AUTO/THEFTS/INDEX.HTML.

A figure of $4,400 probably understates the loss attributed to professional thieves, because joyriders may damage cars and petty thieves may take radios and other equipment. When the average is based on an assumed threshold of a $500 for a professional theft, then the average loss is $5,200. When the threshold is $1,000, the average loss is close to $6,000, and when the threshold is $2,000, the average loss is close to $8,000. For our purposes, the analysis adopts an assumption that the benefit from reducing a theft by a professional thief is $6,000. Assuming that the average benefit from preventing a theft by a professional thief is $6,000 is somewhat conservative, especially given that nonmonetary costs should be taken into account. Never-the less, as seen in the next section, a conservative estimate is adequate for our purposes.

Step 3: Cost of Parts Marking

According to the National Highway Traffic and Safety Administration, the cost of parts marking is trivial—about $5.00 per car (DOT, 1991). Additionally, cars do not have to be marked every year. If the average car is in use for ten years, then the cost per year is only 50 cents per car. Thus, the yearly cost of marking 100,000 cars is $50,000.

The cost of parts marking does not include the additional cost to law enforcement of training and equipping personnel. Given that parts marking assists law enforcement personnel in their investigations, the marginal cost of parts marking to law enforcement may be negative. At any rate, additional costs to law enforcement personnel are not taken into account in this study.

Step 4: Conclusions

Step one provided estimates of the reduction in automobile theft attributed to parts marking and anti-theft devices. Step two gave estimates of the cost of automobile theft to society. Step three reported estimates of the cost of marking parts. This final section ties the first three sections together to assess whether parts marking is cost effective, and whether anti-theft devices are a suitable substitute for parts marking.

This integration of the three sections cannot provide a definitive answer because the estimates themselves are imprecise. The intent in this section is to assemble the best available evidence, and let the reader decide ultimately whether that evidence is sufficient to conclude that parts marking should or should not be extended.

The argument is advanced by specifying a shorthand designation for three kinds of cars. The 1984 Act require NHTSA to identify cars (about one-third of all cars) that had the highest theft rates. We call these HTR cars, or *high theft-rate* cars. HTR cars were designated for parts marking or anti-theft exemptions as of 1987. Estimates of the effectiveness of parts marking presented in step one applies strictly to HTR cars, because they were the only cars that had parts marking between 1987 and 1995. The 1992 Act stipulates that NHTSA identify cars (again, about one-third of all cars) that had average theft rates—that is, theft rates that were lower than those for HTR cars but higher than those for cars with below average theft rates. We designate these as ATR cars, or *average theft rate* cars. The 1992 Act also stipulates that the U.S. Attorney General shall recommend whether or not parts marking should be extended to the remaining cars, which we shall designate as LTR cars, for *low theft-rate* cars. Direct evidence about the effectiveness of parts marking to ATR and LTR cars is practicably unavailable (ATR cars were marked as of 1995), but indirect evidence can be inferred from findings regarding the effectiveness of parts marking and anti-theft devices for HTR cars.

Has parts marking been effective for HTR cars? The best estimates from step one suggest that parts marking has reduced automobile theft by 33 to 165 cars per 100,000 cars that are marked. The cost to the consumer of marking these cars is about $5 per car. Assuming that a car is in use for an average of ten years, marking 100,000 cars costs about $50,000 per year. In step two, we argued that each of these stolen cars costs its owner (or his or her insurance company) about $6,000. Using the $6,000 figure, and assuming the estimate of 33 fewer stolen cars per 100,000 marked cars, the benefit from marking HTR cars has been almost $2 million per 100,000 cars while the cost has been about $50,000 per 100,000 cars. Parts marking appears to have been cost effective for HTR cars.

We are uncertain about each of the estimates used above. Note, however, that parts marking of HTR cars would have been cost beneficial even if victim loss was $2,700, the average victim loss from a stolen car, which would seem to underestimate victim losses for cars stolen by professional thieves. That is, the $2,700 estimate is the average for car thefts for cars stolen by joyriders and by professional thieves combined. It is almost certainly too low as an estimate of the loss from cars stolen by professional thieves, because with exceptions, cars stolen by professionals are either never returned or returned with major parts missing.

Even the estimate of 33 fewer thefts per 100,000 registered cars may be too high of an estimate, and we can ask: How few car thefts must be deterred to make parts marking cost effective. Given that parts marking costs about $50,000 per 100,000 marked cars, and assuming that a stolen car costs its victim (or the insurance company) $6,000, then the parts marking is cost effective if as few as 8.33 car thefts are prevented per 100,000 marked cars. The $6,000 figure seems very conservative given that high theft rates cars tend to be more expensive the typical cars. At $8,000 per car, the critical value would be 6.25 cars per 100,000 marked; at $10,000 per car, the critical value would be 5 fewer thefts per 100,000 marked cars.

If the marking of HTR cars has been cost effective, what can be said about the cost effectiveness of marking ATR and LTR cars? We cannot observe how car marking has affected the theft of ATR cars, so we must reason by analogy. Adopting the $6,000 figure for the cost of a ATR or LTR car, we know that parts marking must deter 8.33 cars per 100,000 that are marked for parts marking to be cost effective. This figure would be achieved if parts marking were to be only 25 percent as effective with ATR and LTR cars as it is with HTR cars. This seems entirely plausible. Another way to look at this problem is to note that about 450 ATR/LTR cars are stolen each year per 100,000 registration. Reducing the theft rate by 7 percent would make parts marking cost effective. This may not seem like an unreasonable achievement, and the figure would be less than 7 percent if stolen cars were valued at more than $6,000.

The Department of Justice also asked Abt Associates to evaluate whether anti-theft devices are a suitable substitute for parts marking. Although the analysis showed that anti-theft devices can reduce automobile thefts, the effectiveness of anti-theft devices is almost surely understated in the analysis reported earlier. Even if this were not true, the analysis does not provide a sound basis for saying whether anti-theft devices are good substitutes for parts marking.

The problem is that parts marking and anti-theft devices serve different purposes. Parts marking is a tool for law enforcement. By allowing police to identify stolen parts, it allows them to make stronger cases against those criminals who deal in stolen cars and their parts, and it allows prosecutors to secure more and better convictions. Improved law enforcement can work by deterring criminals from trafficking in stolen parts, and by dismantling the organizations of criminals who persist. Anti-theft devices are different. They increase the difficulty of stealing a car in the first place, and in that regard, they probably reduce thefts for joyriding (which should be unaffected by parts marking) in addition to thefts for profit. In this regard, it is difficult to see why anti-theft devices should be considered as a substitute for parts marking, and thus, why anti-theft devices marking waivers should be granted for manufacturers who install anti-theft devices as standard equipment.

Possibly, anti-theft devices could reduce the automobile theft rate to a level that was so low that parts marking would cease to be cost effective. To test this, we would need to have time-series cross-sectional data that identify cars that have their parts marked but not anti-theft devices, cars that have anti-theft devices but not parts marking, cars that have both, and cars that have neither. With such data, we could infer the extent to which anti-theft devices are a substitute for parts marking. Suitable data for this analysis are not available.

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